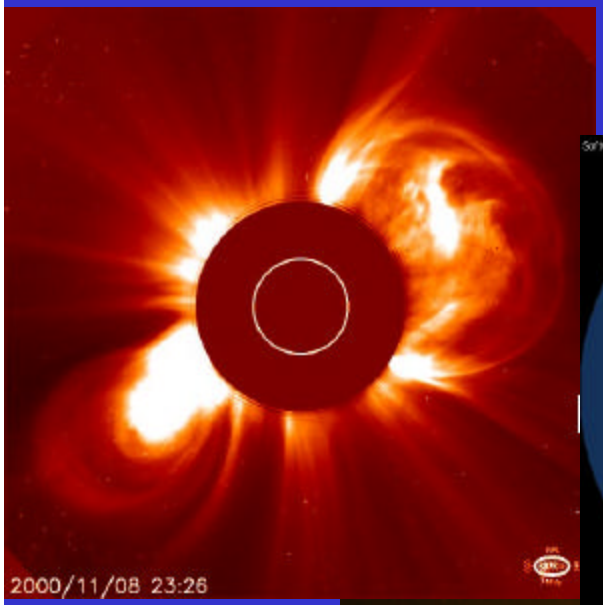
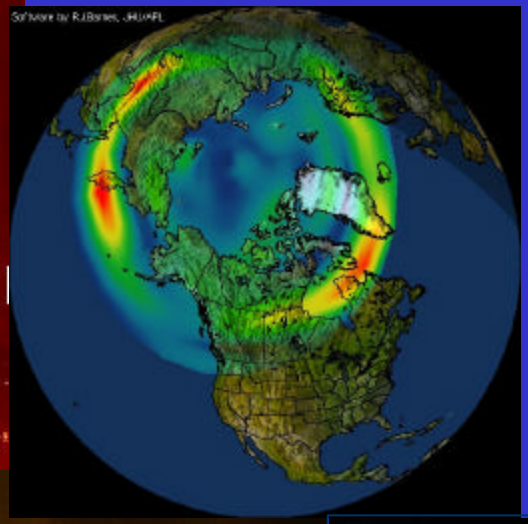
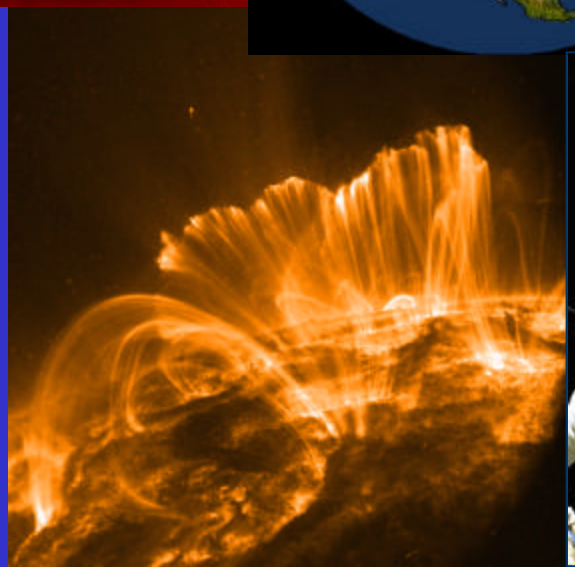
NASA's Contribution to International Living With a Star





Madhulika Guhathakurta
Office of Space Science, CodeSS
NASA Headquarters

October 17,2002

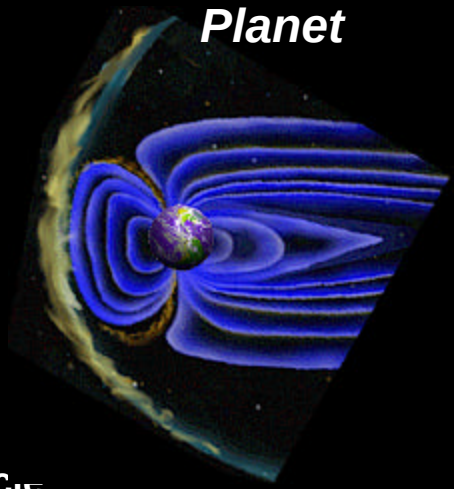


Sun-Earth Connection (Sec) Program

Variable Star

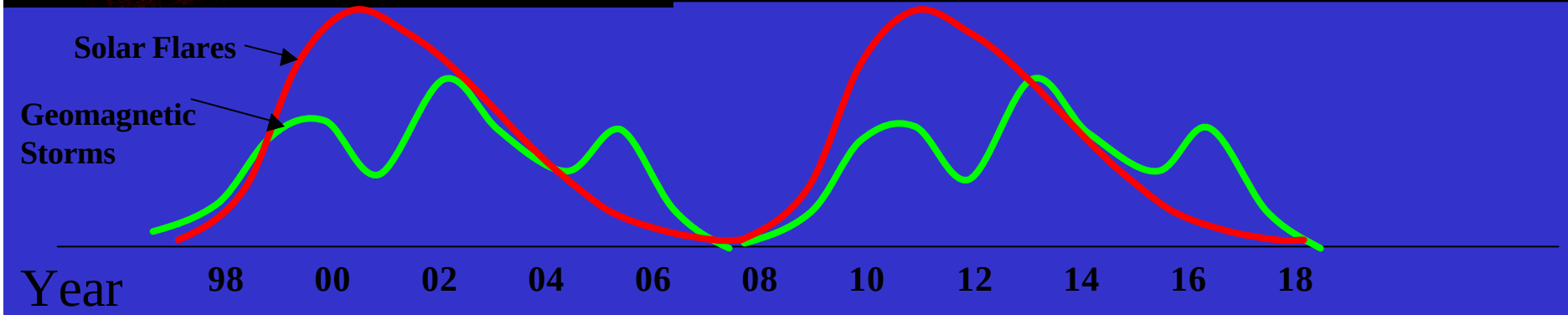
Varying

- **Radiation**
- **Solar Wind**
- **Energetic Particles**



Planet

Driven by 11 Year Solar Cycle



Understanding the changing Sun and its effects on the Solar System, life, and society is one of the goals of the Sun-Earth Connection Theme.

SEC Program Elements

- **Strategic Plans**
  - **2002 is an important year for SEC Strategic Planning**
- **Operating Missions**
  - **Currently 14 operating missions support the research program**
- **Program Mission Lines**
  - **There are two SEC mission lines:**
    - **Solar Terrestrial Probes (STP)**
    - **Living With a Star (LWS)**
- **Cross-Divisional Mission Lines**
  - **There are two mission lines operated for the benefit of the Office of Space Sciences:**
    - **Explorer Mission Line**
    - **New Millennium Technology Mission Line**
- **Supporting Research and Technology Program**

Strategic Planning for SEC

2002 is a significant year for the SEC Division

- **National Academy of Sciences:**

"The Sun to the Earth – and Beyond An Integrated Strategy for Solar and Space Physics, 2003-2013"

Report of the NRC's Solar and Space Physics Survey Committee, L.J. Lanzerotti and J.L. Burch, 6 August 2002

- **Sun-Earth Connection Advisory Subcommittee Roadmap Document (Reviewed every two years)**

Report to the Space Science Advisory Committee, 4 September 2002

- **Office of Space Sciences Strategic Plan**

Anticipated November 2002

- **NRC and SECAS committees validate LWS and STP flight mission scientific goals and priority**

SEC Division Scientific Objectives

SEC Strategic Goal: ***Understand how the Sun, heliosphere, and the planets are connected in a single system.***

- **Explore the fundamental physical processes of plasma systems in the universe**

- **Understand the changing flow of energy & matter throughout the sun, heliosphere, and planetary environments**

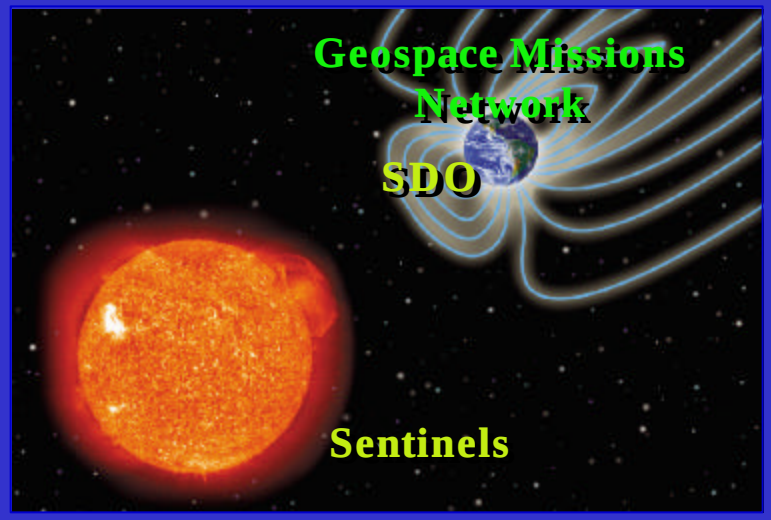
- **Define the origins and societal impacts of variability in the Sun-Earth Connection**

SEC Flight Missions

- **Operating Missions**
  - **Distant Heliospheric missions**
    - VOYAGER, ULYSSES
  - **L1 *in situ* sensing missions**
    - ACE, SOHO (solar wind instruments), and WIND
  - **Solar remote sensing missions**
    - SOHO, TRACE, and RHESSI
  - **Magnetospheric/Ionospheric missions**
    - CLUSTER, FAST, GEOTAIL, IMAGE, POLAR, and SAMPEX
  - **Earth's Mesosphere**
    - TIMED

Indicates prime mission phase

SEC Flight Mission Programs



Current LWS Missions

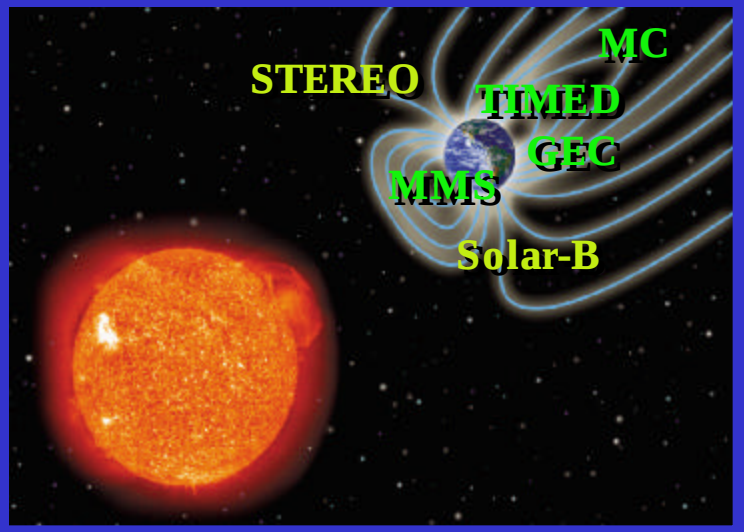
Living With a Star (LWS)

- Missions to characterize the integrated Sun-Earth System behavior and identify the critical physics that link parts of the system
- Program Elements Include:

  1) A Space Weather Research Network

  2) Theory, Modeling, & Data Analysis Program

  3) Space Environment Testbeds (SETs)

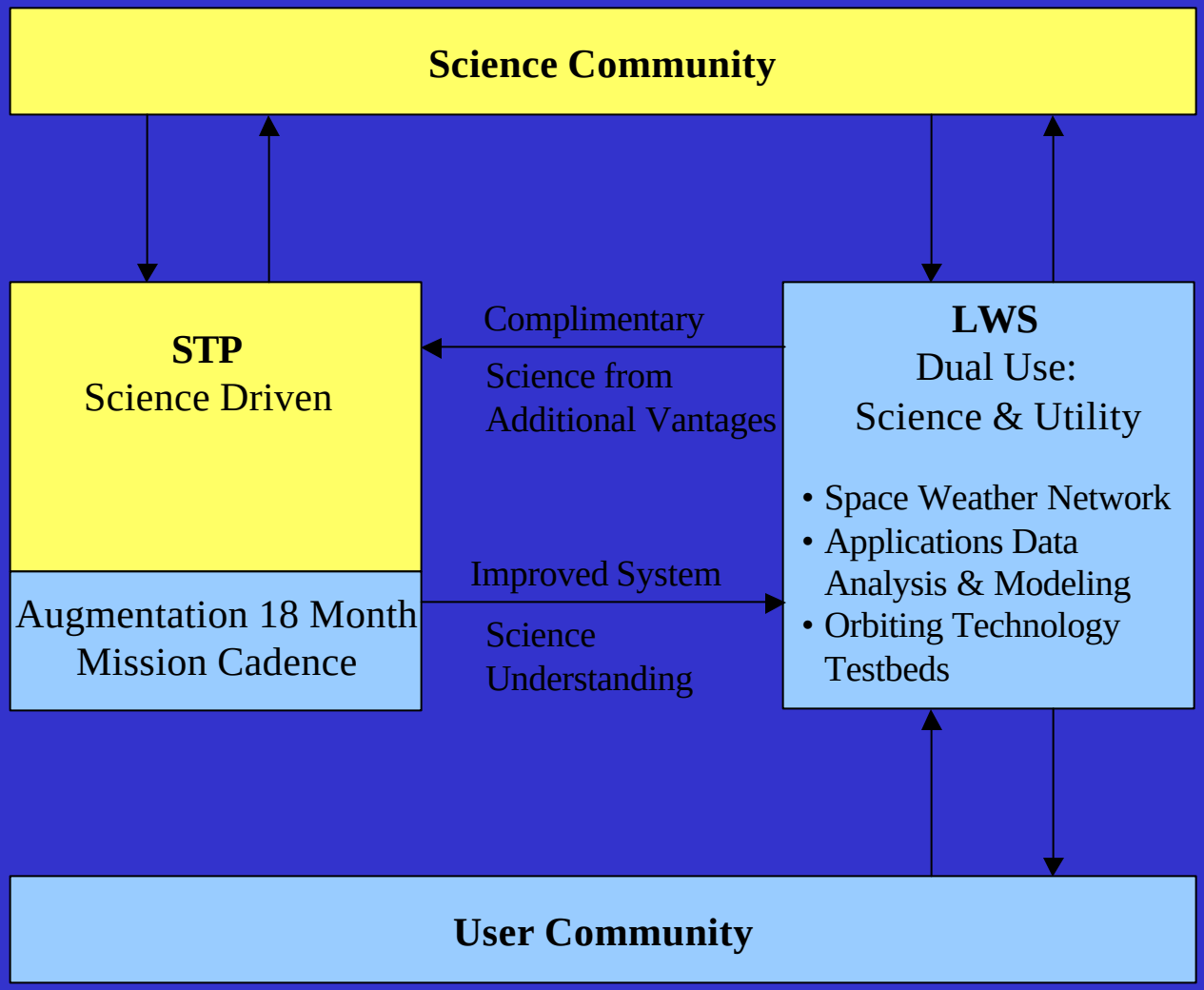


Current STP Missions

Solar Terrestrial Probes (STP)

- Missions with focused investigations to explore specific scientific research questions

Program Relationships
Solar Terrestrial Probes (STP) and Living with a Star (LWS)



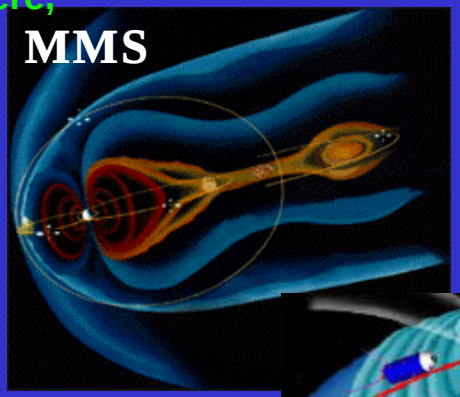
Solar Terrestrial Probes (STP) Program

- **A strategic element of the Sun-Earth Connection Science Roadmap**
- **A continuous sequence of flexible missions designed for the sustained study of critical aspects of the connected Sun-Earth system**
- **A creative blend of in-situ and remote sensing observations, from multiple platforms, addressing focused science objectives**
- **The community-selected initial Solar Terrestrial Probes are:**
  - **Thermosphere Ionosphere Mesosphere Energetics Dynamics (TIMED) (Launched 12/07/01)**
  - **Solar-B**
  - **Solar-Terrestrial Relations Observatory (STEREO)**
  - **Magnetospheric Multiscale (MMS)**
  - **Global Electrodynamic Connections (GEC)**
  - **Magnetospheric Constellation (MC)**

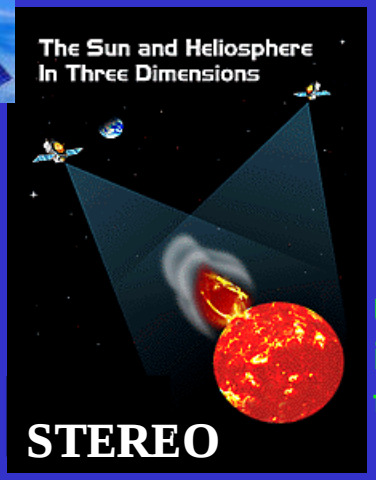
Solar Terrestrial Probes (STP)

SOLAR TERRESTRIAL PROBES
NASA GODDARD SPACE FLIGHT CENTER

Determine basic structure and understand energy balance of mesosphere, lower thermosphere, ionosphere

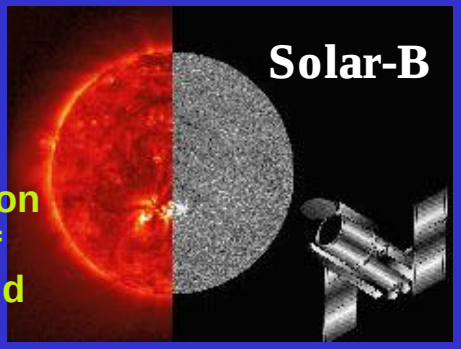


Understand fundamental plasma processes of reconnection, acceleration and turbulence



Understand origin, evolution, and propagation of CME's

Understand plasma interactions with the atmosphere



Understand creation and destruction of solar magnetic field

Understand processes that control the dynamic state and energy flow of the magnetosphere

MC

SEC LWS PROGRAM ELEMENTS

- **Solar Dynamics Observatory**
  - **Three investigations selected in August 2002 for phase A development**
- **Geospace Missions**
  - **Geospace Mission Definition Team identifies the Ionospheric-Termospheric Mapper and Radiation Belt Mapper Missions as highest priority.**
- **Space Environment Testbeds**
  - **Draft NRA written and circulated**
- **Targeted Research and Technology (aka Theory Modeling and Data Analysis)**
  - **TRT goals and priorities team selected and announced (J.Gosling, chair)**
- **Solar Probe Mission**
  - **Applied Physics Laboratory Team report (December 2002)**

Living With A Star (LWS) Program

- A strategic element of the Sun-Earth Connection Science Roadmap
- Utilizes a systems approach to develop the scientific understanding necessary to effectively address those aspects of the connected Sun-Earth system that directly affect life and society
- Implemented by a sequence of inter-related missions
- The initial LWS strategic missions are:
  - Solar Dynamics Observatory (SDO)
  - Geospace Missions Network
  - Sentinels
  - Solar Probe

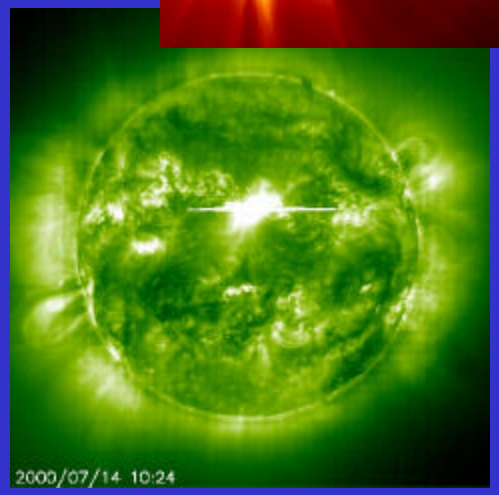
The Solar Dynamics Observatory (SDO)

Goal

Observe the Sun's dynamics to increase understanding of the nature and sources of solar variations

Focus areas

- *Origin, structure and variability of the Sun's magnetic field*
- *Relationships between the Sun's magnetic field and solar mass and energy releases*



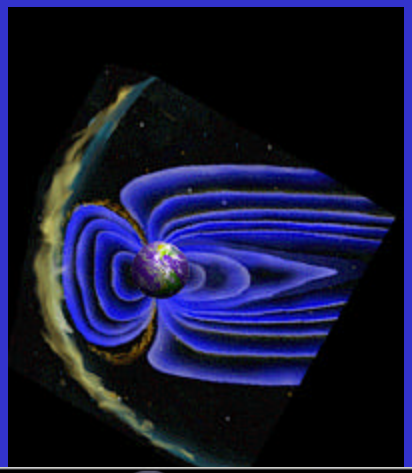
The Geospace Missions Network

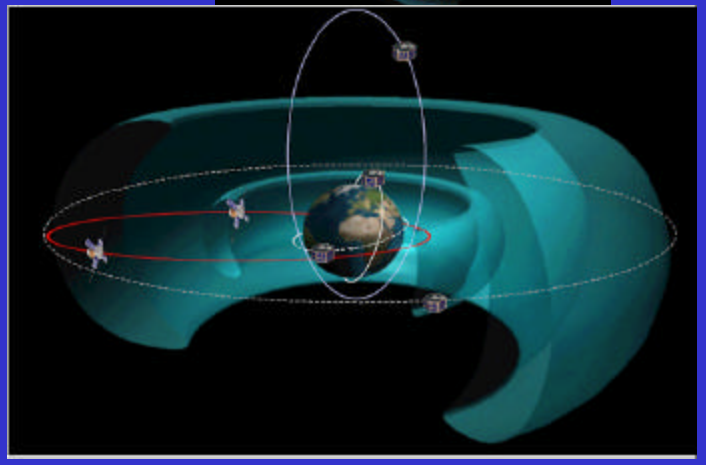
Goal

Increase scientific understanding of how the Earth's ionosphere and magnetosphere respond to changes due to solar variability

Focus areas

- **Radiation belts**
  - **Origin and dynamics of the radiation belts**
  - **Evolution of the radiation belts during magnetic storms**
- **Ionosphere**
  - **Effects of changes in ionizing radiation on the ionosphere**
  - **Variations of neutral density and drag, plasma density and drifts, *scintillations, auroras, and winds***





The Solar Sentinel Missions

Goal

Understand the transition and evolution of eruptions and flares from the Sun to the Earth's magnetosphere

Focus areas

- ***Determine the structure and long-term climatic variations of the ambient solar wind in the inner heliosphere***
- ***Determine how geo-effective solar wind structures propagate and evolve in the inner heliosphere***
- ***Determine what solar dynamic processes are responsible for the release of geo-effective events***
- ***Determine how and where energetic particles are released and accelerated***

Status

- ***Mission architecture under study with International Living With a Star (ILWS) partners***
- ***Launch – TBD***

Space Environment Testbed Products

Bridge the Gap Between Science, Engineering, & User Application Communities

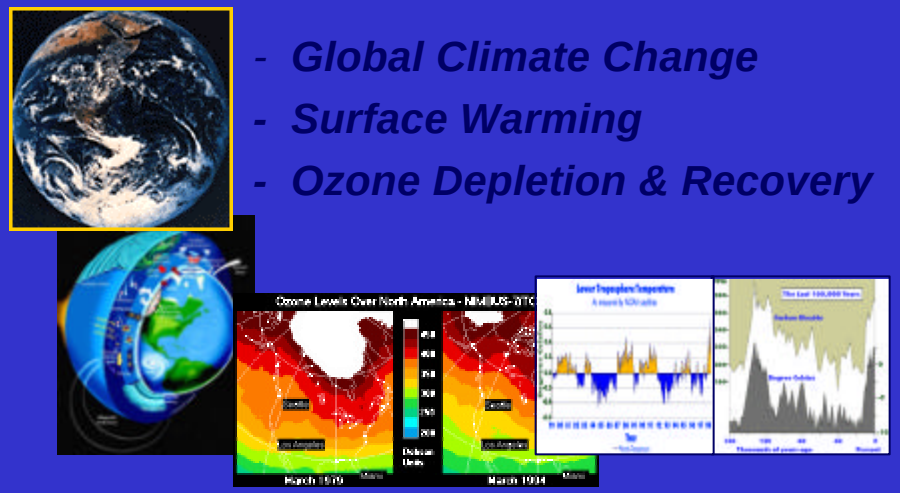
Human Radiation Exposure

- ***Space Station***
- ***Space Exploration***
- ***High Altitude Flight***
- ***Space Utilization & Colonization***

Impacts on Technology

- ***Space Systems***
- ***Communication & Navigation***
- ***Aircraft Systems***
- ***Ground Systems***

Impacts on Life & Society



- ***Global Climate Change***
- ***Surface Warming***
- ***Ozone Depletion & Recovery***

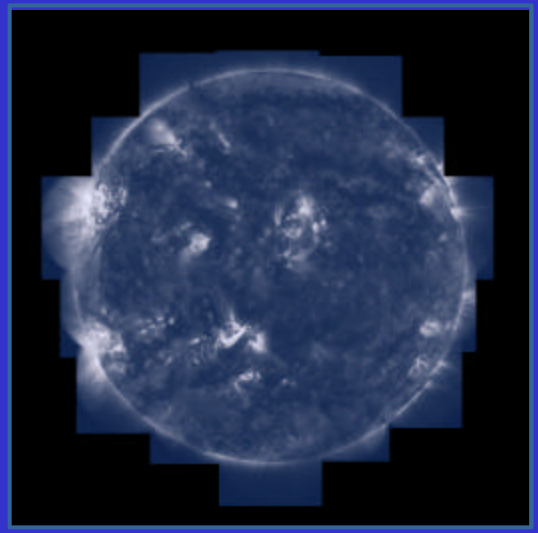
Living With A Star, Theory, Modeling And Data Analysis (TMDA)

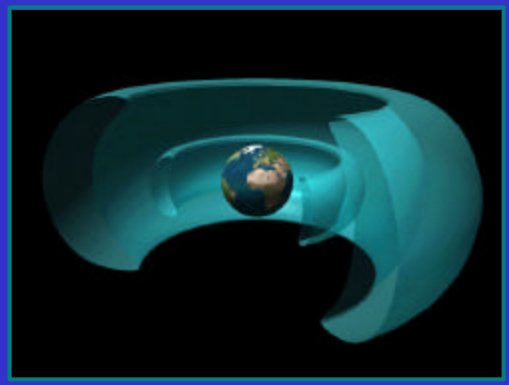
Objective

Perform research to refine the understanding of space weather physics & the role of solar variability in terrestrial climate change

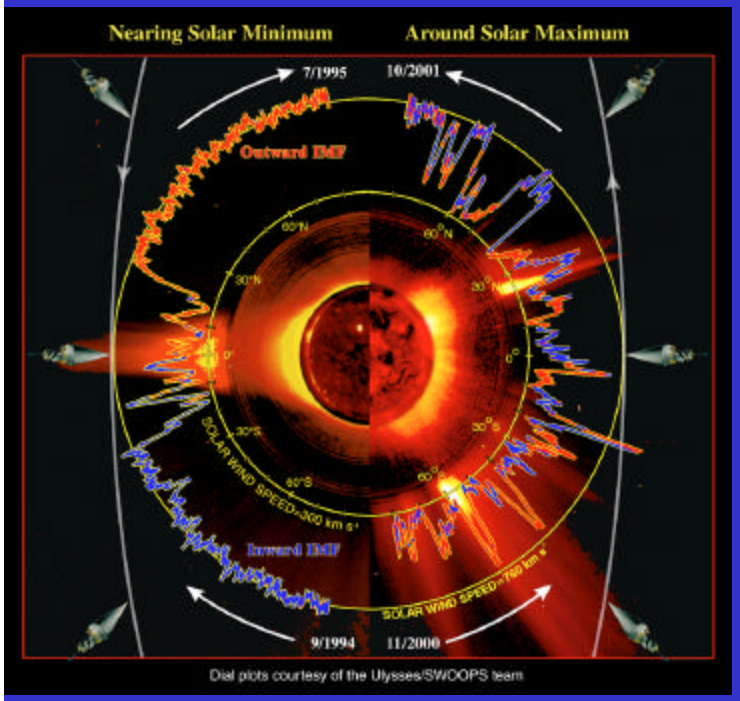
Approach

- ***Develop new instrument techniques, models, and concepts for investigating solar and geospace disturbances***
- ***Improve scientific knowledge of space environment conditions and variations over the solar cycle***
- ***Improve understanding of the effects of solar variability on long-term climate change***
- ***Improve the environment specification models & predictive capability***
- ***Issue of yearly Research Opportunities in Space Sciences (ROSS) Announcement of Opportunity***





Solar Probe



Status

- *JPL developed implementation plan during FY01*
- *FY02 President's Budget cancelled mission*
- *FY02 Congressional Budget Funded mission in FY02 only ($3M)*
  - *Mid-term progress report August 2002*
  - *Final study report with cost analysis due December 2002*
  - *Mission assigned to APL*

Cross-Divisional Flight Mission Lines

- SEC manages two Cross-Divisional Flight Mission Programs
- New Millennium missions develop and flight validate innovative technology
- Explorer Missions target at augmentation of Code S program with SMEX and MIDEX missions.
- Both New Millennium and Explorer missions proposed from SEC experimenters have been selected for investigation.

New Millinium Technology

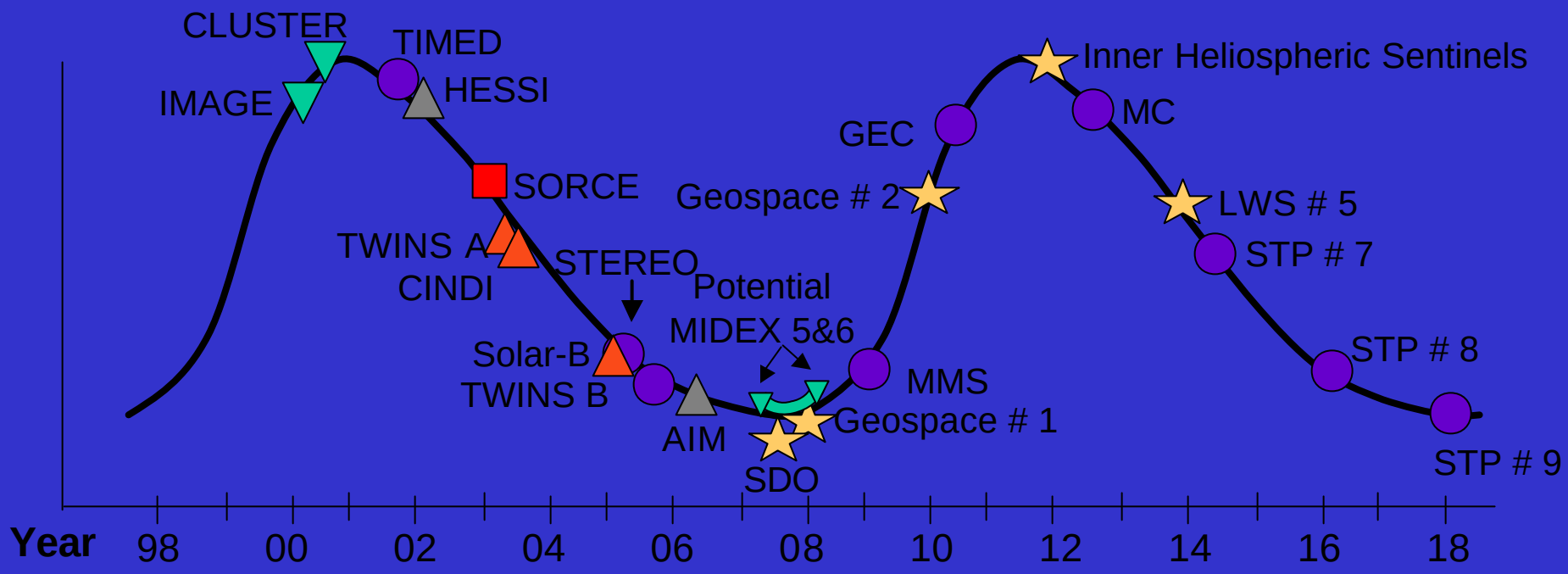
- **ST - 5**

ST- 5 is a technology development mission aimed at flight validation of new spacecraft techniques required for the development of mullti-spacecraft missions such as the STP Mag Con mission.

SEC Explorer Missions

- **Two MoOs in development**
  - **CINDI - Ionospheric experiment on C/NOFS) satellite**
  - **TWINS- Two-s/c ENA imager experiment**
- **Two SEC MIDEX phase A competitors**
  - **THEMIS- magnetic substorm investigation**
  - **ASCE - solar coronal investigation**
  - **Downselect expected winter 2003**
- **AIM - SMEX Phase A Study**
  - **Polar mesospheric cloud investigation**

SEC Strategic Plan



STP Missions

Earth Science Missions

Small Explorer Mission

Medium Explorer Mission

LWS Missions

Explorer Mission of Opportunity

07/10/02

Back up slides